TITLE PAGE

Title: Care Trajectories of Veterans in the Twelve Months following Hospitalization for Acute Ischemic Stroke

Authors: Greg Arling, PhD, Susan Ofner, MS, Mathew J. Reeves, PhD, Laura J. Myers, PhD, Linda S. Williams, MD, Joanne K. Daggy, PhD, Michael S. Phipps, MD, Neale Chumbler, PhD, Dawn M. Bravata, MD.

From Stroke Quality Enhancement Research Initiative (G.A., L.J.M., L.S.W., D.M.B.) and Center for Health Information and Communication (L.J.M., J.K.D., D.M.B.), Roudebush Veterans Affairs Medical Center, Indianapolis, IN; School of Nursing and Center for Aging and the Life Course, Purdue University, West Lafayette, IN (G.A.); Department of Epidemiology, Michigan State University, East Lansing, MI (M.J.R.); Department of Biostatistics (S.O., J.K.D), Department of Neurology (L.S.W.), and Department of Internal Medicine and Geriatrics (D.M.B., L.J.M.), Indiana University School of Medicine, and Regenstrief Institute (L.S.W., D.M.B.), Indianapolis, IN; Department of Neurology, University of Maryland School of Medicine and Baltimore VA Medical Center, Baltimore, MD (M.S.P.); College of Health and Human Services, Western Kentucky University, Bowling Green, KY (N.C.).

Correspondence: Greg Arling, PhD, School of Nursing, Purdue University, West Lafayette, IN 47907-2069, 765-494-6506, garling@purdue.edu

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ABSTRACT

Background. Recovery following a stroke varies greatly between individuals and is reflected by wide variation in the use of institutional and home care services. This study sought to classify Veterans according to their care trajectories in the 12-months after hospitalization for ischemic stroke.

Methods and Results. The sample consisted of 3,811 veterans hospitalized for ischemic stroke in Veterans Health Administration facilities in 2007. Three outcomes—nursing home care, home care, and mortality—were modeled jointly over 12 months using Latent Class Growth Analysis. Data on Veterans' care use and cost came from the Veterans Administration and Medicare. Covariates included stroke severity (NIHSS), functional status (FIM score), age, marital status, chronic conditions, and pre-stroke ambulation. Five care trajectories were identified: 49% of Veterans had Rapid Recovery with little or no use of care; 15% had a Steady Recovery with initially high nursing home or home care that tapered off; 9% had Long-Term Home Care; 13% had Long-Term Nursing Home Care; and 14% had an Unstable trajectory with multiple transitions between long-term and acute care settings. Care use was greatest for individuals with more severe strokes, lower functioning at hospital discharge, and older age. Average annual costs were highest for individuals with the Long-Term Nursing Home trajectory ($63,082), closely followed by individuals with the Unstable trajectory ($58,720). Individual with the Rapid Recovery trajectory had the lowest costs ($9,271).

Conclusions. Care trajectories after stroke were associated with stroke severity and functional dependency and they had a dramatic impact on subsequent costs.

Key words: Stroke, outcomes research, nursing home, home care, cost

INTRODUCTION

Stroke is the leading cause of acute-onset adult disability in the US and more people are surviving stroke than at any time previously.[1] Yet, we know relatively little about the long-term recovery patterns of individuals after stroke. Of particular importance from a policy perspective is the use of post-acute care, including rehabilitation, re-hospitalization, and nursing facility and home care.

Care patterns in the immediate period post-stroke can be complex. Kind and colleagues[2] studied care transitions of stroke patients within 30 days of acute care discharge; one-fifth of patients experienced at least one complex transition defined as movement to a higher intensity care setting. Brown and colleagues found that younger age and greater independence in the motor component of the Functional Independence Measure (FIM) at admission to inpatient rehabilitation were significantly related to discharge home after rehabilitation[3]. Social factors and access to rehabilitation can influence service use and other outcomes after a stroke[4, 5]. Of the handful of studies that have examined longer-term outcomes,[6] some have applied growth analysis methods to model changes over time and to classify individuals into distinct trajectories. For example, Tilling and colleagues employed growth analysis to predict functional recovery in the 12 months after stroke for patients receiving rehabilitation.[7, 8]

The objectives of our study were to apply latent class growth analysis (LCGA) to: (1) identify distinct trajectories of care and recovery after stroke; (2) describe the relationships between care trajectories and patient characteristics; and (3) compare the utilization and cost of care for different trajectories. We analyzed three outcomes: nursing home care, home health care, and mortality. Nursing home and home care have important implications for health care costs as well as quality of life. Mortality is both an important outcome in itself and a competing

risk for other outcomes. We investigated a range of factors that can influence care trajectories: clinical conditions such as stroke severity, comorbidities, and functional dependence; social factors, such as marital status and race/ethnicity; and access to rehabilitation and the setting in which it occurs. By gaining an understanding of care trajectories and their implications for costs and service use, we hope to inform clinical decisions and improve care delivery for victims of stroke.

METHODS

We modeled the 12-month care trajectories for a cohort of patients in the Veterans Health Administration (VA) who were hospitalized for acute ischemic stroke. We examined relationships between care trajectories and patient characteristics measured before or during the index acute stroke hospitalization, as well as service use and costs associated with each trajectory.

All relevant VA and University research review committees approved the study.

Study Cohort

The initial sample consisted of 3965 Veterans admitted to VA medical centers (VAMCs) during October 2006 – September 2007 for an acute ischemic stroke.[9] For this analysis, we excluded patients with in-hospital death, or discharge against medical advice, to another inpatient facility, or with comfort care only or hospice. The resulting analytic sample was 3811 patients discharged from 129 VAMCs.

Study Variables

Patient data were obtained from VA chart review or extracted from VA administrative systems and Centers for Medicare and Medicaid Services (CMS). Data on inpatient and outpatient utilization at VA facilities or paid for by the VA at non-VA facilities (fee-basis care) came from the VA administrative system. Costs for VA and fee-basis care were obtained from the VA Managerial Cost Accounting System. The CMS data on utilization and costs were drawn from Medicare Outpatient, Skilled Nursing, Hospice, and Home Health files. Additional data on Medicaid and private pay nursing home stays came from CMS's nursing home Minimum Data Set (MDS). The VA costs are reported as actual costs, including fixed costs, indirect costs and variable costs (e.g., supplies); CMS data pertain to Medicare payments.

Three main outcomes—nursing home care, home care, and mortality—were examined in 12 monthly intervals during the one-year period following discharge from the index hospitalization. Nursing home and home care were coded as discrete variables if the individual used care at any time during the month. We also recorded number of acute care hospitalizations (VA and CMS) and inpatient and outpatient rehabilitation services (VA and CMS) over the 12-month period. Inpatient rehabilitation included transfer to an inpatient unit within the VHA hospital or admission to inpatient rehabilitation in another facility. Nursing facility use was categorized as a post-acute (or sub-acute) stay with rehabilitation, or a post-acute or longer-term stay without rehabilitation. Neither acute hospitalizations nor rehabilitation were modeled as outcomes because they would have added considerable complexity to the LCGA. We did not include utilization or costs for other forms of care, such as ambulatory care, pharmacy, or medical equipment, nor did we have data on Medicaid payments.

The NIH Stroke Scale (NIHSS) score was measured at admission to the index hospitalization through a standard retrospective analysis of admission physical examination

data.[10] Disability was measured by Motor, Cognitive, and Total scores on Functional Independence Measure (FIM)[11] assessments administered closest to the date of discharge. Past medical history included heart failure, chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), myocardial infarction (MI), hypertension, diabetes, dementia, cerebrovascular disease, and atrial fibrillation. Demographic variables included age, gender, marital status, and race/ethnicity; pre-stroke ambulatory status and nursing facility residence; and index hospitalization length of stay. FIM scores were unavailable for 960 (25%) individuals. Small numbers of individuals had missing race (71), marital status (15) and pre stroke residence (21).

Analysis

Care trajectories were identified with latent class growth analysis (LGGA), a person-centered approach that identifies distinct classes of individuals that are similar with respect to outcomes.[12-14] Classes are assumed to represent sub-populations having distinct growth patterns and outcome distributions. The observed distribution of outcomes in the overall sample is assumed to be a mixture of subpopulation distributions, representing different latent care trajectories.[12-14] Latent patterns in outcomes, such as care trajectories, would not be directly observable or easily pre-specified using traditional modeling approaches.

In the LCGA analysis, we jointly modeled nursing home stay and use of home care as binary outcomes, and mortality as a discrete-time survival distribution over the 12 months post-discharge. All three outcomes could occur in the same month. Growth factors were estimated separately for nursing home stays and home care use; however, the three processes (nursing home, home care and death) were included in the model simultaneously. This model assumes that within each latent class, outcomes are independent Bernoulli random variables and

associations between outcomes are incorporated into the model as the probability of belonging to the latent class variable. We began by specifying a two-class model and then expanded the model with additional classes until achieving the best fit and arriving at classes that were most meaningful clinically. We evaluated model fit with Bayesian Information Criteria (BIC) [15, 16], entropy and overall model interpretability and parsimony [17]. Details of the LCGA are in the Supplement Material (Supplemental Table I).

We compared the characteristics of patients having different trajectories with cross-tabulations, and bivariate and multinomial logistic regression analysis. We tested for statistically significant differences ($p<0.05$) between each care trajectory contrasted with the Rapid Recovery trajectory. The multinomial regression model included only those patient characteristics that were associated with trajectory type at the $p < .10$ level in bivariate regression models. All predictor variables were defined as dichotomies. The multinomial regression model included a facility random effect to address clustering within facilities. Missing FIM score was entered as a dummy variable. We refit the multinomial model after adding post-discharge rehabilitation variables to test their additive relationship to outcomes. To assess predictive accuracy of patient characteristics and rehabilitation use, we ran separate logistic regression models for each trajectory compared to all others and then calculated C-statistics.

We also compared service use and costs for the trajectories by service use and costs, overall and by setting. In addition, total costs for each trajectory were adjusted for patient characteristics using a two-part (logit and mean cost) gamma distribution with patient characteristics serving as covariates. Additional adjusters were the wage index for each VA Medical Center and a mortality indicator (yes/no) to adjust for high costs leading up to death. Adjusted mean costs for each trajectory and the associated 95% confidence intervals are reported

with all covariate values set at their mean. MPlus [18] was used for the LCGA. Other statistical analyses were conducted with SAS V9.2 (Cary, NC).

RESULTS

The study sample was overwhelming male (98%), just over half were age 65 or older (54%), and almost a half were either divorced (31%) or widowed (12%). Sixty-nine percent were white non-Hispanic, 24% African American and 7% Hispanic or other ethnic/racial groups. Length of stay for their index hospitalization averaged 6.8 days. Ninety-five percent were living at home prior to the stroke. Exactly half of the sample had mild strokes (NIHSS 0-2), 40% moderate strokes (NIHSS 3-9) and 10% severe strokes (NIHSS ≥10). Among the 2,851 patients with FIM scores, 37% had complete independence (FIM=6-7), 45% modified dependence (FIM=3-5), and 18% complete dependence (FIM=0-2) on the Total FIM. On the Cognitive FIM, 59% had complete independence (FIM=6-7), 27% had modified dependence (FIM=3-5), and 14% complete dependence (FIM=0-2). On the Motor FIM, 32% were completely independent (FIM=6-7), 42% modified dependence (FIM=3-5) and 26% complete dependence (FIM=0-2). Prior medical conditions included diabetes (40%), stroke (29%), CAD (28%), hypertension (79%), COPD (16%), atrial fibrillation (16%), heart failure (12%), MI (11%), and dementia (8%).

Thirty percent of the sample had at least one nursing home stay and 20% received home health or other home care. Four percent died within 30-days of discharge. Forty-nine percent received some type of rehabilitation within 90 days post-discharge: 20% in a nursing facility, 8% in an inpatient rehabilitation facility or unit, 4% in a home care setting, and 29% as an outpatient. During the 12-month period following stroke discharge, 16% died, half of the cohort had at least

one re-hospitalization, and patients spent an average of 8.5 months living at home without home care.

Care Trajectories

The LCGA yielded 5 latent classes (trajectories) representing the best fit over the 12-month period for the three outcomes of nursing home use, home care, and mortality [See Supplement Material]. Members of the cohort had one of the following five trajectories: 49% had a Rapid Recovery trajectory with little or no use of care over the 12 months; 15% had a Steady Recovery trajectory with initially high nursing or home care that tapered off over a 1-3 month period; 9% had a Long-Term Home Care trajectory with consistently high home care use over the 12 months, 13% had a Long-Term Nursing Home trajectory with consistently high nursing home use over the 12 months, and 14% had an Unstable trajectory with multiple transitions between nursing home, home care and acute care. Figures 1a and 1b display the monthly probabilities of nursing home use and home care for each of the 5 trajectories.

Patient Characteristics by Trajectory

Characteristics of individuals with the 5 trajectories are described in Table 1. Table 2 presents results from a multivariable multinomial model with independent relationships between patient characteristics and care trajectory. This model allows us to assess the importance of each patient characteristic while controlling for the effects of other variables. Adjusted odds ratios (aOR) for each of the four trajectories are in comparison to the Rapid Recovery trajectory. Nearly all statistically significant relationships in the bivariate analysis remained significant in the multivariable model.

Individuals age 65 or older were least likely to have Rapid Recovery and most likely have a Long Term Nursing Home trajectory. Higher percentages of white non-Hispanics had the

Rapid Recovery and Long-Term Nursing trajectories compared to the other trajectories. African Americans were significantly more likely than whites to experience a Steady Recovery, Long-Term Home Care, or Unstable trajectory. Married individuals were most likely to have a Long-Term Home Care or Steady Recovery and least likely to have an Unstable or Long Term Nursing Home trajectory. Individuals with and Long Term Nursing Home trajectory had the longest index hospitalization stays and those with Rapid Recovery had the shortest stays. Being ambulatory pre-stroke and having a prior residence in a nursing home were most strongly associated with a Long-Term Nursing Home trajectory.

Stroke severity and functional dependency (FIM) were associated most strongly with care trajectories. Having a moderate to severe stroke or being moderately to completely dependent on the Cognitive, Motor, or Total FIM made a Rapid Recovery trajectory much less likely and a Long Term Nursing Home trajectory much more likely. When compared to Rapid Recovery, an individual who was completely dependent on the Total FIM had an aOR of 16.16 for experiencing a Long Term Nursing Home trajectory. The aOR for a person in the moderate dependence category was 9.47. Having a severe stroke and being completely dependent on the Total FIM also significantly increased the likelihood of a Long Term Home Care or Unstable trajectory. Individuals with a Rapid Recovery were somewhat less likely to have a history of chronic conditions or comorbidities, although, the number or type of comorbidities was not strongly related to any of the trajectories. Mortality was highest among individuals with a Long Term Nursing Home trajectory and they were highest in the first 30 days after hospital discharge.

The Long-Term Nursing Home Trajectory was best predicted by patient characteristics (Table 2). The C-statistic = .81 indicates very good concordance between predicted and actual trajectory. The Unstable trajectory had the lowest C-statistic of .59 indicating relatively poor

discrimination. The predictive model for Long-Term Home Care trajectory had a modest C-statistic of .72; Rapid Recovery had a modest C-statistic of .74; and Steady Recovery had a low C-statistic of .63.

Table 3 shows service use comparisons by trajectory. Mean nursing home and home care months were greatest for individuals with those trajectories; while mean months at home without care was greatest for individuals with the Rapid Recovery and Steady Recovery trajectories. Hospitalizations in the 12-month period were concentrated in the first 90 days post-discharge and especially in the first 30-days (Table 3, Figure 2). Higher percentages of subjects in the Unstable trajectory had 2 or 3 or more hospitalizations than did individuals in other trajectories.

Rehabilitation by Trajectories

Use of rehabilitation by setting varied significantly by setting (Table 3). The majority of individuals with Long-Term Nursing Home Care, Steady Recovery and Long-Term Home Care trajectories had some form of rehabilitation within 90 days post-discharge from their index hospitalization. Not surprisingly, sub-acute rehabilitation in a nursing home was associated with a Long-Term Nursing Home trajectory. Individuals in the Steady Recovery trajectory were most likely to receive rehabilitation as outpatients. The percentage of individuals receiving inpatient rehabilitation was low, ranging from 14% for the Steady Recovery trajectory to 4% for the Rapid Recovery trajectory.

Since both patient characteristics and use of rehabilitation could influence care trajectories, we examined the effect of adding rehabilitation setting as predictor variables in the multivariable multinomial model in Table 2. Results are presented in Supplemental Table II. When rehabilitation setting within 30 days post-discharge was added to the model, the C-statistic for Steady Recovery went up substantially from .63 to .72. The C-statistics for the other

trajectories increased only slightly. Receiving rehabilitation in a nursing home post-discharge was strongly associated with the Long-Term Nursing Home Trajectory (aOR=8.93), as well as the Unstable (aOR=4.0) and Long-Term Home Care (aOR= 3.6) trajectories. Rehabilitation in an inpatient rehabilitation facility was modestly associated with all four trajectories (aOR range 1.91 to 2.65). Outpatient rehabilitation or rehabilitation with home care was most strongly associated with a Steady Recovery (aOR=5.43) or Long-Term Home Care (aOR=3.34) trajectory. As expected, some adjusted odds ratios for the covariates declined after introducing the rehabilitation variables to the model, yet all covariates remained statistically significant.

Cost by Trajectories

Table 4 shows mean, median, and interquartile range of costs for each care trajectory. The mean 12-month combined VA and Medicare cost per person in the cohort was $28,561. Mean total cost varied substantially by care trajectory: Rapid Recovery ($9,271), Steady Recovery ($19,745), Long-Term Home Care ($47,907), Unstable ($58,720), and Long-Term Nursing Home ($63,082). The highest costs were for inpatient acute care, particularly for individuals with the Unstable trajectory. The Long-Term Nursing Home trajectory had costs spread across inpatient acute care, nursing home with rehabilitation, and nursing home without rehabilitation. Of the mean total 12-month cost, 76.7% ($21,908) came from the VA and 23.3% ($6,653) from Medicare. The 2044 Veterans age 65 or older had a mean 12-month cost of $31,940 with 77.4% ($21,526) from the VA and 32.6% ($10,414) from Medicare.

Since many patient characteristics associated with trajectories might also be associated with costs of care, we estimated the adjusted mean cost per person per trajectory after controlling for patient and characteristics. Details of the analysis are in Supplemental Tables III-V. There was some narrowing of differences after adjustment, yet differences in adjusted mean costs

between trajectories remained substantial and followed a similar pattern as the observed. Figure 3 shows the observed and adjusted total costs with confidence intervals. Individuals with the Long-Term Nursing Home trajectory had the highest mean adjusted costs ($54,744) followed closely by the Unstable ($53,929) trajectories and then by the Long-Term Home Care ($43,597), Steady Recovery ($19,623), and Rapid Recovery ($9,807) trajectories.

DISCUSSION

This study enhances our understanding of care outcomes for Veterans after an ischemic stroke. It advances beyond current literature that has focused primarily on the description of a specific outcome, such as hospital readmissions or mortality, or on overall healthcare utilization and costs in the immediate post-stroke period. The current study describes patients' care trajectories over a one-year period as well as service use and costs associated with those trajectories. It builds on prior studies pointing to the instability of care patterns for some individuals post-stroke[2], and importance of functional dependency[3] and rehabilitation setting in predicting care outcomes.[5, 19]

A key study finding was that nearly half of the cohort had a Rapid Recovery trajectory with little or no use of institutional or home care in the 12 months after stroke. As expected, most individuals with this care trajectory had mild strokes and were functionally independent at discharge. They received little rehabilitation, experienced few acute hospitalizations, and had the lowest VA and Medicare costs. Rapid recovery may be a common pattern in the VA because acute ischemic stroke admissions to VA hospitals appear to have relatively mild spectrum (median NIHSS was 2), although a prior population-based study showed that mild stroke severity is in fact common.[20]

Of great interest from clinical and policy perspectives are the other four trajectories. They were characterized by significantly different patterns of care and costs, as well as important differences in patient characteristics and use of rehabilitation after hospital discharge. Individuals with the Long-Term Nursing Home trajectory had the highest average total annual cost, with about one-third each attributable to nursing home days with rehabilitation, nursing home days without rehabilitation, and inpatient acute care. This trajectory was the most predictable at hospital discharge. Individuals with this trajectory had the greatest functional dependence and most severe strokes; they were oldest and least likely to be married; they had the longest index hospitalization length of stay; and they had the highest mortality rates. The majority of individuals with this trajectory received rehabilitation post-stroke, with about half receiving sub-acute rehabilitation in a nursing home. Receiving rehabilitation in the nursing home was strongly predictive of remaining there even after controlling for functional status and stroke severity. Placement in a nursing home or skilled nursing facility for post-acute rehabilitation is probably indicative of prior health and functional detriments that contribute to the individual remaining in that setting. Alternatively, simply entering a nursing home may itself influence one's care trajectory, particularly in the absence of social or economic resources needed to return to the community.

Individuals with the Long-Term Home Care trajectory had some use of nursing home care early in their trajectories but then settled into continuous use of home care. Their annual cost of care was substantial, although less than individuals with a Long-Term Nursing Home trajectory. This trajectory could be predicted reasonably well by older age, moderate to total functional dependence, and moderate to severe stroke severity. Also a higher percentage of these individuals were married. The majority received rehabilitation post-stroke, mainly in as an

outpatient or at home, findings that suggest they had continued functional deficits that contributed to their extensive home care. Although care at home probably afforded a higher quality of life than in an institution, these individuals had significant ongoing care needs.

The Steady Recovery trajectory was the most desirable pattern for individuals with functional deficits after a stroke. It was characterized by initial nursing home or home care, often accompanied by rehabilitation, with a steady reduction in care over a 90-120 day period post-stroke. Owing to their more limited use of services, the cost of care for individuals in this trajectory was much lower than the other trajectories aside from Rapid Recovery. Potential contributors to their recovery were less severe strokes, greater functional independence at discharge, younger age, and fewer pre-existing chronic conditions. Receipt of rehabilitation on an outpatient basis was strongly associated with the Steady Recovery trajectory, while rehabilitation in an inpatient or nursing home setting was also predictive.

The Unstable trajectory, representing one-seventh of the cohort, had care patterns similar to the complex transitions described over a 30-day period in the study by Kind and colleagues[2], albeit over an extended 12-month period. Individuals with the Unstable trajectory had the highest inpatient acute care costs, accompanied by relatively high nursing home costs. They tended to be older and unmarried. They also had multiple comorbidities, greater functional dependence and more severe strokes, and were most likely to have received rehabilitation in a nursing home. Their use of acute, nursing home and home care was sporadic. This trajectory was the least predictable of the five trajectories. They undoubtedly had unmeasured health events, such as complications from the index stroke, or recurrent strokes, that led to their high rates of re-hospitalization and transitions in and out of the nursing home and home care. The Unstable trajectory merits further study to determine whether more effective rehabilitation, care

coordination, risk factor management, and other strategies could mitigate untoward health events and the bouncing between acute and long-term care settings.

When controlling for health, functioning, age and other personal characteristics, African Americans were less likely to have a Rapid Recovery and more likely to have an Long-Term Home Care, Long-Term Nursing Home or Unstable trajectory. This finding merits further study to explore how social or economic factors, or potential disparities in care, may lead to differences in care trajectories.

Our study had notable strengths. We had a well-defined sample of stroke patients with comprehensive measures of their use of care both within the VA system and from Medicare. Second, LCGA analysis resulted in a five-class model with a set of distinct care trajectories that made clinical sense and fit the data well. Demonstrating that there was a Long-Stay Nursing Home, Home Care, and Rapid Recovery trajectories was not surprising. However, differentiating the Steady Recovery and Unstable trajectories from the other trajectories reflects the strength of the LCGA as an analytical tool. These trajectories would likely not have been identified from a purely descriptive analysis. The LCGA also allowed us to optimize the classification of individuals into each trajectory. Third, we were able to identify variables such FIM score, stroke severity (NIHSS), age, marital status, and number of comorbidities, which distinguished between the care trajectories. Our findings were consistent with prior research pointing to the strong predictive power of the FIM in predicting care outcomes[3] and the role of social factors in influencing care outcomes[4].

Our study also had notable limitations. Generalizability of findings is limited by the sample of predominantly male veterans who obtained much of their care from the VA. Second, there were potential gaps in assessing care utilization outside the VA system. Nursing home care

paid by Medicare was tracked well through the nursing home minimal data set (MDS) and Medicare skilled nursing facility claims, however we lacked data on institutional, home and community-based services that were paid by Medicaid. Third, the analysis focused on predictor variables immediately before or during the index hospitalizations; we lacked data on other health events, changes in health or functioning, social supports and economic status or other factors that could have influenced the care trajectories over time. Fourth, the study took place in 2006-2007. Changes have occurred in the care delivery system in the VA and outside the VA since that time that could further limit generalizability of findings.

Some findings regarding post-stroke rehabilitation were perplexing. Only a minority of individuals received rehabilitation in an inpatient rehabilitation setting, and the rate of use varied little by trajectory type. Sub-acute rehabilitation in the nursing home, the most common setting for rehabilitation, was as expected associated with a Long-Term Nursing Home trajectory for many individuals. Disentangling the complex causal effects between rehabilitation setting and trajectory type is challenging. We cannot draw conclusions about the comparative effectiveness of different rehabilitation settings, particularly an inpatient rehabilitation facility versus a nursing home, because of the potential for selection bias. The organizational context may have been the driving factor, where receiving rehabilitation in the nursing home setting contributed to the individual remaining in that setting. Strong selection effects undoubtedly influence such care patterns; individuals with greater functional dependence or more severe strokes tend to receive their rehabilitation in nursing homes and to remain there. This issue needs more study to disentangle the complex relationships between care setting, receipt of rehabilitation and the individual's health and functional status and social resources.

CONCLUSIONS

The LCGA and the concept of different care trajectories open up opportunities for policy-relevant research. By understanding the dynamics of health and functional change, care utilization and costs, and the patterns of these outcomes over time, we can identify points of intervention and system changes that can lead potentially to more effective care delivery. In earlier studies of this stroke cohort we found opportunities for improved care processes during the inpatient stay[9, 21] and risk management during the post-discharge period[22, 23]. One key intervention point appears to be hospital discharge when the decisions are made about the care setting and access to rehabilitation services. Further work is needed to characterize the modifiable patient and healthcare system factors that are associated with the Unstable trajectory, and to capitalize on factors associated with a Rapid or Steady Recovery trajectory. In particular, we need a better understanding of the interaction between patient characteristics, rehabilitation settings, and outcomes.

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Figure 1a. Monthly Probabilities of Nursing Home by Trajectory

Figure 1b. Monthly Probabilities of Home Care by Trajectories

Figure 2. Acute Hospitalization Rate Post-Discharge by Care Trajectories

Figure 3. Observed and Adjusted Mean Annual Cost per Person

Table 1. Patient Characteristics by Trajectory

	Rapid Recovery (n=1852)	Steady Recovery (n=556)	Long-Term Home Care (n=359)	Long-Term Nursing Home Care (n=503)	Unstable (n=541)
Age 65 or older	45.4%	49.1%	66.3%*	74.8%*	58.6%*
Race					
White Non-Hispanic	71.5%	66.6%	58.4%	70.3%	65.5%
African American	21.8%	25.0%*	31.0%*	24.5%	27.1%*
Other	6.7%	8.4%	10.6%*	5.2%	7.4%
Married	43.5%	50.2%*	51.5%*	34.4%*	38.6%*
Index hospital length of stay (mean, SD)	5.1 (6.2)	6.5 (7.0)*	7.4 (6.5)*	12.3 (14.9)*	7.4 (7.3)*
Nursing home residence pre-stroke	2.4%	1.6%	3.3%	12.3%*	4.3%*
Not ambulatory pre-stroke	3.3%	2.7%	7.0%*	12.1%*	6.1%*
NIH Stroke Severity Scale					
Mild (0-2)[b]	60.4%	46.2%	39.8%	28.8%	45.1%
Moderate (3-9)	34.8%	45.3%*	47.9%*	43.9%*	43.3%*

Severe (10+)	4.8%	8.5%*	12.3%*	27.2%*	11.6%*
FIM Total Categories (n= 2851)[a]					
Complete Independence (0-2)[b]	53.8%	32.5%	17.8%	5.9%	28.4%
Modified Dependence (3-5)	34.8%	56.2%*	60.9%*	49.1%*	50.8%*
Complete Dependence (6-7)	11.5%	11.3%*	21.4%*	45.0%*	20.7%*
FIM Cognitive Categories (n=2851)[a]					
Complete Independence (0-2)[b]	72.8%	60.0%	47.8%	31.7%	52.8%
Modified Dependence (3-5)	17.5%	31.2%*	35.9%*	44.0%*	34.2%*
Complete Dependence (6-7)	9.7%	8.8%	16.3%*	24.3%*	13.0%*
FIM Motor Categories (n=2851)[a]					
Complete Independence (0-2)[b]	46.8%	26.9%	16.3%	5.1%	25.8%
Modified Dependence (3-5)	37.8%	53.7%*	50.0%*	37.6%*	42.2%*
Complete Dependence (6-7)	15.4%	19.4%*	33.7%*	57.3%*	32.0%*
Missing FIM (N=960)	28.4%	20.3%*	23.1%*	22.3%*	23.3%*
Pre-Stroke History of Chronic Diseases					
Hypertension	76.9%	83.1%*	81.6%	78.1%	81.1%*

Heart Failure	8.5%	12.9%*	21.2%*	14.7%*	14.2%*
COPD	12.8%	16.5%*	18.9%*	20.5%*	18.9%*
CAD	24.6%	28.6%	30.1%*	34.0%*	31.6%*
MI	9.0%	11.2%	16.7%*	10.7%	11.5%
Diabetes	36.2%	43.7%*	45.1%*	41.6%*	42.0%*
Dementia	3.4%	5.4%*	12.8%*	17.9%*	10.4%*
Cerebrovascular disease	24.6%	27.5%	35.1%*	35.0%*	35.9%*
Atrial fibrillation	11.9%	12.8%	23.1%*	24.5%*	16.8%*
Count of disease history (mean, SD)	2.1 (1.4)	2.4 (1.4)*	2.8 (1.6)*	2.8 (1.6)*	2.6 (1.5)*
% Dying within 12 Months	11.2%	0.2%*	16.2%*	44.5%*	20.3%*
Months alive (mean, SD)	11.1 (2.8)	12.0 (0.0)*	11.1 (2.3)	8.1 (4.7)*	11.1 (2.2)

*Tests for statistically significant differences ($p<0.05$) between each care trajectory contrasted with the Rapid Recovery trajectory. Tests were based on separate bivariate multinomial regression models where the patient characteristic was the predictor and care trajectories were outcomes.

[a] FIM scores were missing for 960 individuals.

[b] Reference category for variable that was treated as categorical in the hierarchical regression models.

Table 2. Multivariable Multinomial Model Predicting Trajectory Type with Rapid Recovery as the Reference Category, N=3811

		Patient Demographic and Baseline Characteristics (n=3811)		
Covariate	Latent Class	Overall test	p-value	Odds Ratio (95% CI)
Age ≥65	Unstable	<.0001	0.0004	1.45 (1.18,1.79)
	Long-Term Home Care		<.0001	1.84 (1.42,2.39)
	Long-Term Nursing Home Care		<.0001	2.73 (2.12,3.50)
	Steady Recovery		0.9892	1.00 (0.82,1.23)
African American Race	Unstable	<.0001	0.0018	1.45 (1.15,1.83)
(vs. White)	Long-Term Home Care		<.0001	2.03 (1.53,2.70)
	Long-Term Nursing Home Care		0.0390	1.33 (1.01,1.75)
	Steady Recovery		0.0708	1.24 (0.98,1.57)
Other Race (vs. White)	Unstable	0.0184	0.6218	1.10 (0.75,1.63)
	Long-Term Home Care		0.0147	1.72 (1.11,2.67)
	Long-Term Nursing Home Care		0.0926	0.65 (0.40,1.07)
	Steady Recovery		0.3718	1.19 (0.81,1.73)
Married	Unstable	<.0001	0.0019	0.72 (0.59,0.89)

	Long-Term Home Care		0.2562	1.15 (0.90,1.47)
	Long-Term Nursing Home Care		<.0001	0.54 (0.42,0.68)
	Steady Recovery		0.0293	1.25 (1.02,1.52)
Lived in Nursing Home pre stroke	Unstable	0.0057	0.9897	1.00 (0.58,1.73)
	Long-Term Home Care		0.3559	0.72 (0.36,1.44)
	Long-Term Nursing Home Care		0.0162	1.77 (1.11,2.82)
	Steady Recovery		0.1378	0.57 (0.27,1.20)
Not Ambulatory Pre Stroke	Unstable	0.1731	0.3353	1.26 (0.79,2.00)
	Long-Term Home Care		0.2607	1.36 (0.80,2.30)
	Long-Term Nursing Home Care		0.1056	1.44 (0.93,2.23)
	Steady Recovery		0.2584	0.71 (0.39,1.29)
Number of Comorbidities	Unstable	<.0001	<.0001	1.26 (1.18,1.35)
	Long-Term Home Care		<.0001	1.36 (1.26,1.48)
	Long-Term Nursing Home Care		<.0001	1.23 (1.14,1.33)
	Steady Recovery		<.0001	1.17 (1.09,1.26)
FIM Missing	Unstable	<.0001	0.0388	1.35 (1.02,1.78)

	Long-Term Home Care		0.0006	1.97 (1.34,2.91)
	Long-Term Nursing Home Care		<.0001	5.19 (3.22,8.36)
	Steady Recovery		0.7050	1.05 (0.80,1.39)
FIM Total completely dependent	Unstable	<.0001	<.0001	2.32 (1.63,3.31)
	Long-Term Home Care		<.0001	3.33 (2.11,5.27)
	Long-Term Nursing Home Care		<.0001	16.15 (9.81,26.59)
	Steady Recovery		0.1695	1.31 (0.89,1.94)
FIM Total moderately dependent	Unstable	<.0001	<.0001	2.35 (1.81,3.05)
	Long-Term Home Care		<.0001	4.08 (2.86,5.82)
	Long-Term Nursing Home Care		<.0001	9.47 (5.99,15.00)
	Steady Recovery		<.0001	2.38 (1.87,3.04)
NIHSS moderate severity	Unstable	<.0001	0.0038	1.37 (1.11,1.69)
	Long-Term Home Care		0.0003	1.62 (1.25,2.10)
	Long-Term Nursing Home Care		<.0001	1.93 (1.50,2.49)
	Steady Recovery		0.0006	1.44 (1.17,1.77)
NIHSS severe	Unstable	<.0001	<.0001	2.21 (1.51,3.23)

	Long-Term Home Care		0.0002	2.36 (1.51,3.69)
	Long-Term Nursing Home Care		<.0001	5.08 (3.52,7.32)
	Steady Recovery		0.0005	2.05 (1.37,3.07)
C statistics for binary outcome	Unstable	0.59		
	Long-Term Home Care	0.72		
	Long-Term Nursing Home Care	0.81		
	Steady Recovery	0.63		
	Rapid Recovery	0.74		

Reference levels for odds ratios are : Age <65, White, non-Hispanic, Not married, Not Living in Nursing Home pre stroke, Ambulatory pre stroke, FIM Total completely independent, NIHSS mild stroke severity

Table 3. Service Use by Trajectory.

	Rapid Recovery (n=1852)	Steady Recovery (n=556)	Long-Term Home Care (n=359)	Long-Term Nursing Home Care (n=503)	Unstable (n=541)
Rehabilitation in 90 Days Post-Discharge					
Any Type	28.3%	75.9%*	72.7%*	68.6%*	56.0%*
Nursing Home	7.4%	17.6%*	27.0%*	54.9%*	31.2%*
Inpatient rehabilitation facility or unit	4.1%	13.5%*	12.8%*	10.3%*	9.4%*
Outpatient	20.1%	58.8%*	46.2%*	17.7%	29.4%*
Home Health	1.2%	9.9%*	12.3%*	1.8%	4.8%*
Nursing home months (mean, SD)	0.2 (0.5)	0.5 (0.7)*	1.2 (1.5)*	7.4 (4.4)*	2.4 (2.1)*
Home care months (mean, SD)	0.1 (0.3)	3.0 (1.5)*	9.1 (2.7)*	0.9 (2.1)*	2.3 (2.0)*
Home without any care months (mean, SD)	10.9 (3.2)	10.2 (1.6)*	3.1 (3.1)*	1.9 (2.8)*	8.1 (3.4)*
Acute hospitalizations post-discharge					
None (reference level)[b]	62.7%	54.5%	35.1%	38.2%	24.0%
1	23.5%	25.5%	23.7%*	33.0%*	26.1%*

	Rapid Recovery (n=1852)	Steady Recovery (n=556)	Long-Term Home Care (n=359)	Long-Term Nursing Home Care (n=503)	Unstable (n=541)
2	8.4%	10.3%*	19.5%*	13.3%*	20.3%*
3+	5.3%	9.7%*	21.7%*	15.5%*	29.6%*

*Tests for statistically significant differences ($p<0.05$) between each care trajectory contrasted with the Rapid Recovery trajectory.

Table 4. Average 12-Month Costs in US dollars per Person by Trajectory and Care Type

Care Type/Setting	Rapid Recovery (N=1852)		Steady Recovery (N=556)		Long-Term Home Care (N=359)	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Inpatient Acute Care	6888 (24942)	0 (5470)	9509 (23841)	0 (8329)	17911 (28717)	7154 (25090)
Nursing Home Care without Rehabilitation	157 (2047)	0 (0)	523 (3035)	0 (0)	3939 (20025)	0 (104)
Home Care without Rehabilitation	65 (414)	0 (0)	1574 (2650)	0 (2336)	9931 (15849)	7289 (10645)
Nursing Home with Rehabilitation	1276 (5261)	0 (0)	3198 (8860)	0 (0)	9349 (21293)	0 (7718)
Home Care with Rehabilitation	13 (190)	0 (0)	347 (1329)	0 (0)	968 (2530)	0 (334)
Inpatient Rehabilitation	773 (4650)	0 (0)	3739 (10919)	0 (0)	4141 (12496)	0 (0)

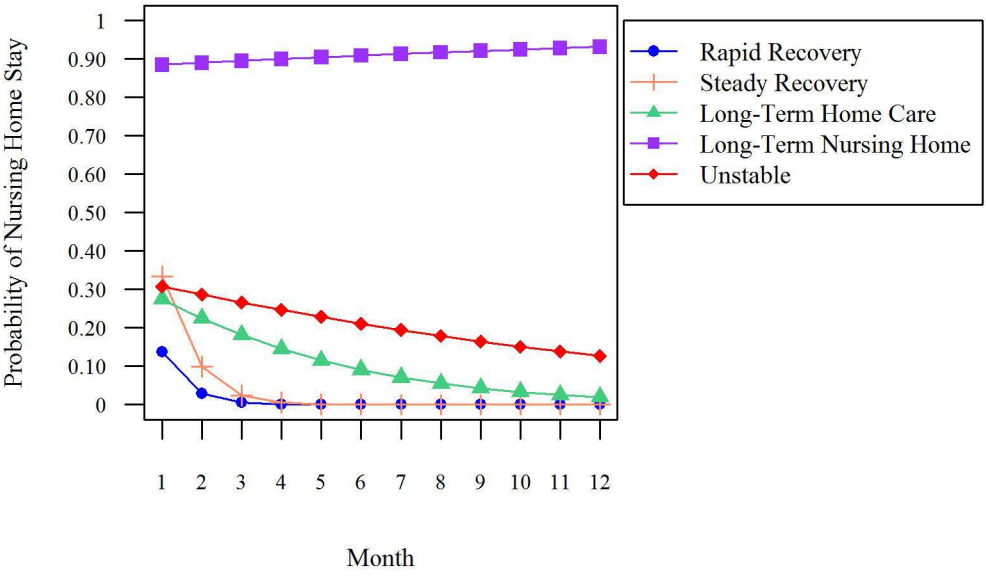
Outpatient						
Rehabilitation	98 (272)	0 (59)	856 (1389)	373 (1054)	1668 (3452)	160 (1357)
Total	9271 (25911)	347 (10747)	19745 (27046)	10342 (25093)	47907 (48824)	34207 (47819)
VA	8359 (25458)	163 (8514)	15248 (24392)	5132 (21050)	35740 (45244)	22618 (42587)
Medicare	912 (4902)	0 (0)	4497 (12334)	0 (4105)	12167 (23599)	2170 (13772)

Table 4. Average 12-Month Costs in US dollars per Person by Trajectory and Care Type (Cont.)

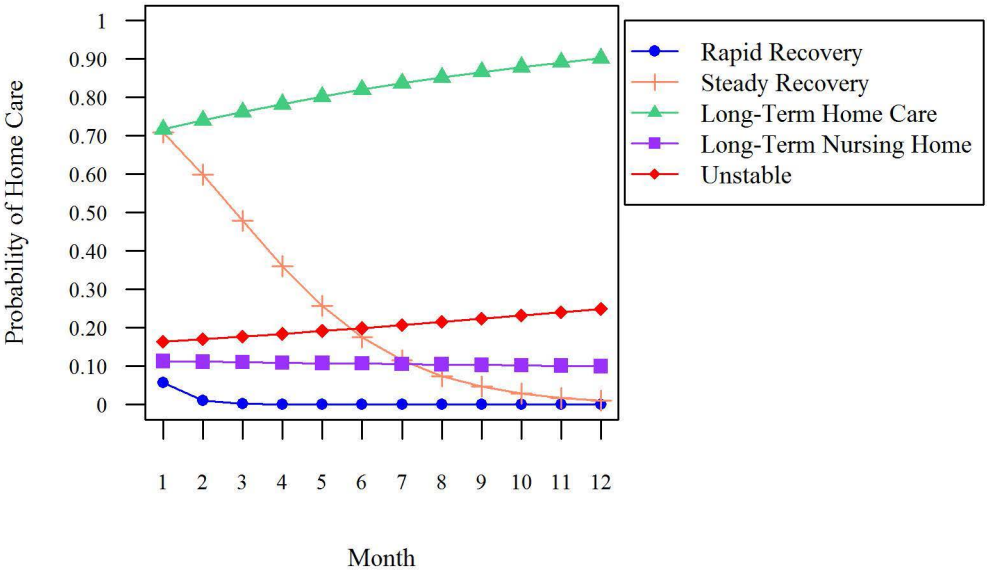
Care Type/Setting	Long-Term Nursing Home (N=503)		Unstable (N=541)	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Inpatient Acute Care	19139 (31559)	5600 (25768)	27058 (39075)	12505 (34273)
Nursing Home Care without Rehabilitation	21550 (65677)	1291 (12579)	9171 (39123)	0 (3342)
Home Care without Rehabilitation	716 (2412)	0 (0)	1553 (2695)	0 (2245)
Nursing Home with Rehabilitation	17037 (26869)	5193 (26011)	15461 (24601)	0 (25820)
Home Care with Rehabilitation	129 (760)	0 (0)	417 (1448)	0 (0)
Inpatient Rehabilitation	4353 (17109)	0 (0)	4633 (14646)	0 (0)
Outpatient Rehabilitation	158 (623)	0 (8)	427 (854)	55 (490)

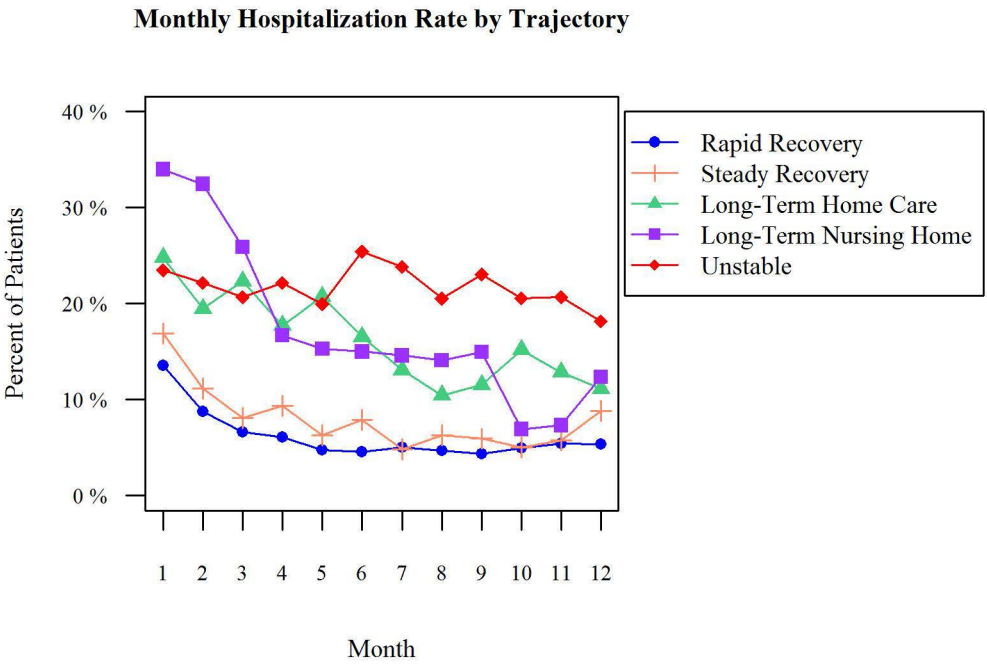
Total	63082 (86034)	38746 (71275)	58720 (64863)	41384 (66756)
VA	44115 (86033)	12945 (48817)	45307 (61684)	26476 (60746)
Medicare	18968 (28520)	5117 (30694)	13413 (26291)	0 (17209)

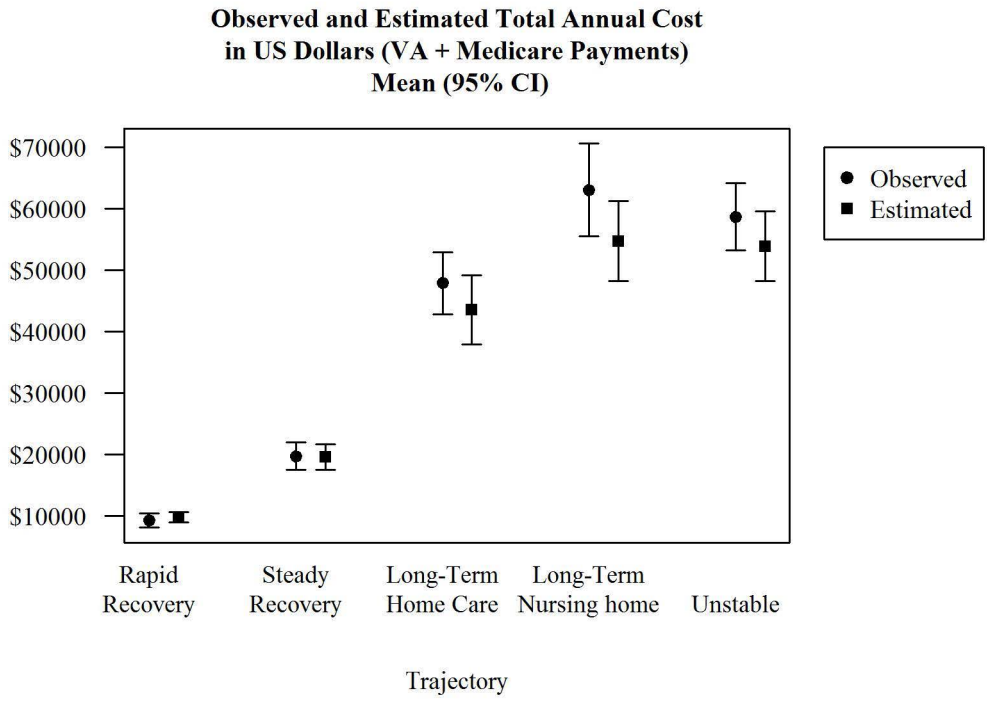
Monthly Probability of Nursing Home Stay by Trajectory



Monthly Probability of Home Care by Trajectory




Monthly Hospitalization Rate by Trajectory
40 %
30 %
20 %
10 %
0 %
Percent of Patients
1
2
3
4
5
6
7
8
9
10
11
12
Month
Rapid Recovery
Steady Recovery
Long-Term Home Care
Long-Term Nursing Home
Unstable


Observed and Estimated Total Annual Cost
in US Dollars (VA + Medicare Payments)
Mean (95% CI)
$70000
$60000
$50000
$40000
$30000
$20000
$10000
Observed
Estimated
Rapid Recovery
Steady Recovery
Long-Term Home Care
Long-Term Nursing home
Unstable
Trajectory

What is Known

- Acute stroke survivors differ in patterns of acute and long-term care after discharge from the hospital.
- Functional dependency and access to rehabilitation can have a bearing on recovery and subsequent care use and costs.

What the Study Adds

- In the twelve months after hospitalization for an acute stroke, Veterans in the study cohort had one of five distinct care trajectories: Rapid Recovery (50%), Steady Recovery (15%); Long-Term Home Care (9%); Long-Term Nursing Home Care (13%); or Unstable (14%).
- Care use was greatest for individuals with more severe strokes, lower functioning at hospital discharge, older age, unmarried, and African American.
- Average annual costs differed dramatically by trajectory: costs were highest for the Long-Term Nursing Home trajectory ($63,082) and Unstable trajectory ($58,720), and lowest for Rapid Recovery trajectory ($9,271).

SUPPLEMENTAL MATERIAL

Supplemental Methods

A. LCGA Models

Our LCGA model jointly modeled two binary outcomes and one discrete survival outcome for the twelve months post discharge. The binary outcomes, nursing home stay and use of home care, could occur in each month the individual was alive over a 12-year period after discharge from the stroke. Mortality was modeled as a discrete-time survival distribution. All three outcomes could occur in the same month. Growth factors were estimated separately for nursing home stays, home care use; however, the three processes (nursing home, home care and death) were included in the model simultaneously. This model assumes that within each latent class, outcomes are independent Bernoulli random variables and associations between outcomes are incorporated into the model as the probability of belonging to the latent class variable. We began by specifying a two-class model and then expanded the model with additional classes until achieving the best fit and arriving at classes that were most meaningful clinically. We evaluated model fit with Bayesian Information Criteria (BIC) [1, 2], entropy and overall model interpretability and parsimony [3]. Analysis was performed with MPlus software[4].

We fit models with 2 to 5 latent classes and compared examined the log likelihood and the Bayesian Information Criteria (BIC). Among 4 models tested (i.e., 2, 3, 4 and 5 classes), log likelihoods ranged from -30660 for 2 classes to -24353 for 5 classes and the Bayesian Information Criteria (BIC) ranged from 61494 to 49300. Entropy for 2 to 5 classes ranged from 0.94 to 0.91. We settled on using the 5-class model since it showed the best model fit. Model statistics are displayed in Table I. Individual subjects were assigned to a particular class based on the highest predicted probability from the 5-class model.

B. Multilevel Models Predicting Trajectory Type

We examined associations between patient characteristics and care trajectory through multivariable multinomial analysis with VAMC as a random effect. The multinomial model used the five trajectories as the outcomes and included patient characteristics as predictor variables. The outcomes were: Long Term Nursing Home, Long Term Home Care, Steady Recovery, Unstable, and Rapid Recovery as the reference level. The basic model, without rehabilitation variables is in the first set of columns in Table II. The expanded multinomial model included rehabilitation setting in the 30 days post discharge to the set of patient characteristics as predictors. Table II presents the p-values and odds ratios with 95% confidence intervals.

C. Observed and Estimated Costs of Care

We estimated mean total cost of care (VA and Medicare) per person for each trajectory after adjusting for covariates. The trajectories were Long Term Nursing Home (LTNH), Long Term Home Care (LTHC), Steady Recovery (SR), Unstable (U), and Rapid Recovery (RR). Adjusted costs per trajectory were estimated with a non-linear mixed model (SAS NLMIXED) using two-part gamma distribution. In the first part we modeled the probability of a cost > 0 (yes/no) with a

logit link function. In the second part we modeled mean costs for individuals having a positive costs.

Covariates included in both the logit part and the mean positive cost models included: Age (≥65 vs. < 65), Married (Yes vs. No), lived in nursing Home pre-index admission, not ambulatory, number of comorbidities, FIM (complete dependence, moderate dependence, complete independence, missing), NIHSS (0-2, 3-9, 10+). Additional covariates only included in mean positive cost: Wage index and death indicator. The wage index associated with each VA Medical Center helps adjust for regional differences in health care costs. The death indicator identifies individuals who died at any point during the 12-month period.

Table III observed and adjusted mean cost with associated 95% confidence intervals. Adjusted means are estimated at observed mean of covariates. Tables IV contains the proportion of each trajectory with cost > 0. Table V shows findings from the predictive models.

Supplemental Tables

Table I. Results from the 5 Class Latent Growth Curve Models

Log Likelihood	AIC	BIC	Entropy	Latent Class Description	Latent Class	class n (%)	Outcome	Intercept (se)	Slope (se)
-24353.3	48850.7	49300.4	0.907	Unstable	1	541 (14.2)	Nursing Home	-0.117 (0.234)	-0.102 (0.043)
							Home Health	-2.523 (0.356)	0.048 (0.026)
				Long Term Home Care	2	359 (9.4)	Nursing Home	-0.279 (0.196)	-0.266 (0.061)
							Home Health	0.036 (0.229)	0.118 (0.033)
				Rapid Recovery	3	1852 (48.6)	Nursing Home	-1.143 (0.153)	-1.678 (0.143)
							Home Health	-3.698 (-0.215)	-1.691 (0.259)
				Long Term Nursing Home Care	4	503 (13.2)	Nursing Home	2.734 (0.366)	0.052 (0.051)
							Home Health	-2.953 (0.222)	-0.012 (0.029)
				Steady Recovery	5	556 (14.6)	Nursing Home	0.000 (0.000)	-1.510 (0.181)
							Home Health	0.000 (0.000)	-0.488 (0.050)

Table II. Multivariable Multinomial Model Predicting Trajectory Type with Rapid Recovery as the Reference Category

Covariate	Latent Class	Patient Demographic and Baseline Characteristics (n=3811)			Includes Rehab Setting in 30 days Post Discharge Indicators (n=3811)		
		Overall test	p-value	Odds Ratio (95% CI)	Overall test	p-value	Odds Ratio (95% CI)
Age ≥65	Unstable	<.0001	0.0004	1.45 (1.18,1.79)	<.0001	0.0030	1.38 (1.12,1.70)
	Long Term Home Care		<.0001	1.84 (1.42,2.39)		<.0001	1.79 (1.37,2.33)
	Long Term Nursing Home Care		<.0001	2.73 (2.12,3.50)		<.0001	2.39 (1.84,3.10)
	Steady Recovery		0.9892	1.00 (0.82,1.23)		0.9488	0.99 (0.80,1.23)
African American Race (vs White)	Unstable	<.0001	0.0018	1.45 (1.15,1.83)	<.0001	0.0008	1.50 (1.18,1.90)
	Long Term Home Care		<.0001	2.03 (1.53,2.70)		<.0001	2.09 (1.57,2.79)
	Long Term Nursing Home Care		0.0390	1.33 (1.01,1.75)		0.0160	1.41 (1.07,1.87)
	Steady Recovery		0.0708	1.24 (0.98,1.57)		0.0784	1.25 (0.98,1.60)
Other Race (vs White)	Unstable	0.0184	0.6218	1.10 (0.75,1.63)	0.0378	0.7341	1.07 (0.72,1.59)
	Long Term Home Care		0.0147	1.72 (1.11,2.67)		0.0281	1.65 (1.06,2.59)
	Long Term Nursing Home Care		0.0926	0.65 (0.40,1.07)		0.0983	0.65 (0.39,1.08)
	Steady Recovery		0.3718	1.19 (0.81,1.73)		0.7009	1.08 (0.72,1.61)
Married	Unstable	<.0001	0.0019	0.72 (0.59,0.89)	<.0001	0.0164	0.77 (0.63,0.95)
	Long Term Home Care		0.2562	1.15 (0.90,1.47)		0.1700	1.19 (0.93,1.52)
	Long Term Nursing Home Care		<.0001	0.54 (0.42,0.68)		<.0001	0.59 (0.46,0.75)
	Steady Recovery		0.0293	1.25 (1.02,1.52)		0.0306	1.26 (1.02,1.55)
Lived in Nursing Home pre stroke	Unstable	0.0057	0.9897	1.00 (0.58,1.73)	0.0002	0.4796	1.22 (0.70,2.12)
	Long Term Home Care		0.3559	0.72 (0.36,1.44)		0.9038	0.96 (0.47,1.94)
	Long Term Nursing		0.0162	1.77 (1.11,2.82)		0.0001	2.61 (1.62,4.23)

Covariate	Latent Class	Patient Demographic and Baseline Characteristics (n=3811)			Includes Rehab Setting in 30 days Post Discharge Indicators (n=3811)		
		Overall test	p-value	Odds Ratio (95% CI)	Overall test	p-value	Odds Ratio (95% CI)
	Home Care						
	Steady Recovery		0.1378	0.57 (0.27,1.20)		0.5805	0.81 (0.38,1.73)
Not Ambulatory Pre Stroke	Unstable	0.1731	0.3353	1.26 (0.79,2.00)	0.1384	0.2891	1.29 (0.81,2.07)
	Long Term Home Care		0.2607	1.36 (0.80,2.30)		0.2174	1.40 (0.82,2.41)
	Long Term Nursing Home Care		0.1056	1.44 (0.93,2.23)		0.0560	1.56 (0.99,2.45)
	Steady Recovery		0.2584	0.71 (0.39,1.29)		0.3554	0.75 (0.41,1.38)
Number of Comorbidities	Unstable	<.0001	<.0001	1.26 (1.18,1.35)	<.0001	<.0001	1.26 (1.18,1.35)
	Long Term Home Care		<.0001	1.36 (1.26,1.48)		<.0001	1.38 (1.27,1.51)
	Long Term Nursing Home Care		<.0001	1.23 (1.14,1.33)		<.0001	1.24 (1.15,1.35)
	Steady Recovery		<.0001	1.17 (1.09,1.26)		<.0001	1.19 (1.11,1.28)
FIM Missing	Unstable	<.0001	0.0388	1.35 (1.02,1.78)	<.0001	0.0957	1.27 (0.96,1.69)
	Long Term Home Care		0.0006	1.97 (1.34,2.91)		0.0009	1.94 (1.31,2.88)
	Long Term Nursing Home Care		<.0001	5.19 (3.22,8.36)		<.0001	4.23 (2.61,6.88)
	Steady Recovery		0.7050	1.05 (0.80,1.39)		0.5624	1.09 (0.82,1.45)
FIM Total completely dependent	Unstable	<.0001	<.0001	2.32 (1.63,3.31)	<.0001	0.0009	1.86 (1.29,2.68)
	Long Term Home Care		<.0001	3.33 (2.11,5.27)		<.0001	2.89 (1.81,4.63)
	Long Term Nursing Home Care		<.0001	16.15 (9.81,26.59)		<.0001	9.82 (5.88,16.41)
	Steady Recovery		0.1695	1.31 (0.89,1.94)		0.2001	1.31 (0.87,1.96)
FIM Total moderately dependent	Unstable	<.0001	<.0001	2.35 (1.81,3.05)	<.0001	0.0005	1.64 (1.24,2.16)
	Long Term Home Care		<.0001	4.08 (2.86,5.82)		<.0001	2.90 (2.01,4.20)
	Long Term Nursing Home Care		<.0001	9.47 (5.99,15.00)		<.0001	4.80 (2.99,7.72)
	Steady Recovery		<.0001	2.38 (1.87,3.04)		<.0001	1.81 (1.38,2.36)

Covariate	Latent Class	Patient Demographic and Baseline Characteristics (n=3811)			Includes Rehab Setting in 30 days Post Discharge Indicators (n=3811)		
		Overall test	p-value	Odds Ratio (95% CI)	Overall test	p-value	Odds Ratio (95% CI)
NIHSS moderate severity	Unstable	<.0001	0.0038	1.37 (1.11,1.69)	0.0421	0.1778	1.16 (0.93,1.45)
	Long Term Home Care		0.0003	1.62 (1.25,2.10)		0.0316	1.34 (1.03,1.75)
	Long Term Nursing Home Care		<.0001	1.93 (1.50,2.49)		0.0078	1.43 (1.10,1.87)
	Steady Recovery		0.0006	1.44 (1.17,1.77)		0.1676	1.17 (0.94,1.45)
NIHSS severe	Unstable	<.0001	<.0001	2.21 (1.51,3.23)	<.0001	0.0013	1.90 (1.28,2.80)
	Long Term Home Care		0.0002	2.36 (1.51,3.69)		0.0030	2.00 (1.27,3.15)
	Long Term Nursing Home Care		<.0001	5.08 (3.52,7.32)		<.0001	3.93 (2.68,5.77)
	Steady Recovery		0.0005	2.05 (1.37,3.07)		0.0119	1.72 (1.13,2.63)
Post-acute Rehabilitation in 30 days post discharge	Unstable				<.0001	<.0001	4.09 (3.11,5.40)
	Long Term Home Care					<.0001	3.66 (2.63,5.09)
	Long Term Nursing Home Care					<.0001	8.93 (6.72,11.88)
	Steady Recovery					<.0001	2.72 (1.99,3.72)
Inpatient Rehabilitation in 30 days post discharge	Unstable				<.0001	0.0021	1.91 (1.27,2.88)
	Long Term Home Care					0.0001	2.49 (1.60,3.88)
	Long Term Nursing Home Care					<.0001	2.65 (1.70,4.12)
	Steady Recovery					<.0001	2.55 (1.74,3.73)
Outpatient or Home Rehabilitation in 30 days post discharge	Unstable				<.0001	0.0004	1.64 (1.24,2.15)
	Long Term Home Care					<.0001	3.34 (2.49,4.46)
	Long Term Nursing Home Care					0.0102	1.56 (1.11,2.20)
	Steady Recovery					<.0001	5.43 (4.32,6.83)
C statistics for binary outcome	Unstable	0.59			0.61		
	Long Term Home	0.72			0.74		

Covariate	Latent Class	Patient Demographic and Baseline Characteristics (n=3811)			Includes Rehab Setting in 30 days Post Discharge Indicators (n=3811)		
		Overall test	p-value	Odds Ratio (95% CI)	Overall test	p-value	Odds Ratio (95% CI)
	Care						
	Long Term Nursing Home Care	0.81			0.84		
	Steady Recovery	0.63			0.72		
	Rapid Recovery	0.74			0.79		

Reference levels for odds ratios are : Age <65, White, non-Hispanic, Not married, Not Living in Nursing Home pre stroke, Ambulatory pre stroke, FIM Total completely independent, NIHSS mild stroke severity

Table III: Estimated total costs in US Dollars (VA total cost + Medicare Payments), N = 3,811 patients (600 died)

Class	N	N Died	Estimated†		Observed‡			
			Mean	95% CI	Mean	95% CI	Median	IQR
Rapid Recovery	1852	207	9,807	[8,986, 10,627]	9,271	[8,090, 10,452]	347	10,747
Unstable	541	110	53,929	[48,230, 59,627]	58,720	[53,242, 64,198]	41,384	66,756
Long-term HC	359	58	43,597	[37,946, 49,248]	47,907	[42,839, 52,974]	34,207	47,819
Long-term NH	503	224	54,744	[48,220, 61,268]	63,082	[55,546, 70,619]	38,746	71,275
Steady Recovery	556	1	19,623	[17,569, 21,678]	19,745	[17,492, 21,998]	10,342	25,093

‡Raw mean of total costs

†Estimated mean and 95% CI obtained from NLMIXED using two-part gamma model at observed mean of covariates. Covariates included in both the logit part and the mean positive cost include: Age (≥65 vs. < 65), Married (Yes vs. No), lived in nursing home pre-index admission, not ambulatory, number of comorbidities, FIM (complete dependence, moderate dependence, complete independence, missing), NIHSS. Additional covariates only included in mean positive cost: Wage index and death indicator.

Table IV. Proportion of Patients with Costs > 0

Trajectory	N	Observed proportion of patients with cost > 0
RR	1852	.594
U	541	.985
LTHC	359	1.0
LTNH	503	.940
SR	556	.995

Table V. Parameter Estimates from Two-Part Gamma Model

	Parameter	Estimate	t-Value	p-value
Covariates in mean				
Age (≥65)	-0.083	0.047	-1.76	0.079
Married	-0.005	0.047	-0.11	0.916
Lived NH	0.008	0.118	0.07	0.942
Not ambulatory	-0.116	0.104	-1.12	0.263
Number of comorbidities	0.068	0.016	4.27	<.0001
FIM complete dependence	0.226	0.082	2.75	0.006
FIM moderate dependence	0.279	0.062	4.49	<.0001
FIM missing	0.092	0.067	1.37	0.170
NIHSS (3-9)	0.163	0.049	3.36	0.001
NIHSS3 (10+)	0.241	0.082	2.95	0.003
Wage index	0.260	0.140	1.87	0.062
Death indicator	0.323	0.063	5.09	<.0001
beta0 (RR)	8.994	0.155	58.21	<.0001
betaU	1.263	0.066	19.04	<.0001
betaLTHC	1.039	0.077	13.49	<.0001
betaLTNH	1.328	0.072	18.52	<.0001
betaSR	0.241	0.066	3.63	0.0003
Covariates in logit				
Age (≥65)	0.178	0.098	1.81	0.070
Married	-0.094	0.095	-0.98	0.327
Lived NH	-0.557	0.272	-2.05	0.041
Not ambulatory	-0.106	0.248	-0.43	0.670
N comorbidities	0.085	0.035	2.41	0.016
FIM complete dependence	0.446	0.182	2.45	0.014
FIM moderate dependence	0.903	0.128	7.05	<.0001
FIM missing	0.312	0.114	2.74	0.006
NIHSS (3-9)	0.440	0.104	4.23	<.0001
NIHSS (10+)	0.12	0.20	-0.48	0.629
alpha0 (RR)	-0.290	0.112	-2.58	0.010
alphaU	3.667	0.360	10.18	<.0001
alphaLTNH	2.155	0.212	10.18	<.0001
alphaSR	5.149	0.581	8.86	<.0001
phi	1.492	0.033	45.78	<.0001

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